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Design and Implementation of Aurdino Based Smart Home Energy Management System Using Renewable Energy Resources

***S.Nagalakshmi, M.Prabha, R.Senthamarai and G.Rohini**

Department of EEE, Sethu Institute of Technology, Kariapatti, India

Abstract : Energy Management System (EMS) is a computer-aided tool used by power system operators to monitor and controls the power flows in the micro grid by adjusting the power imported/exported from/to the main grid, the dispatchable DERs and the controllable of the market, the generations, and the loads in order to meet the operational objectives. The proposed work focuses on the design and development of Arduino controlled Smart Home Energy Management System (SHEMS) using Renewable Resources for micro grid with an objective to manage the load demand by using distribution grid supply, renewable resources like solar, wind and Lead Acid Battery to minimize the rate of energy consumption. This also minimizes harmful gas emissions and improves energy utilization efficiency. In this work, Arduino controller is employed to monitor and control the energy generation and consumption of smart home .This work enhances the usage of renewable energy at home to perform energy saving and to reduce CO_2 emissions.

Introduction

Energy is the backbone of all human activities on the earth. Fossil fuels have served and fulfilled all human needs from energy for long era. With the constant fluctuating oil prices and the environmental problems that arise due to the increased usage of fossil fuels, on a universal basis has demanded transition from conventional fossil fuel based and centralized energy generation into a low carbon and energy efficient economy. To sustain radical growth rates, a sustainable supply of energy is of paramount importance. Renewable energy resources such as solar, wind, ocean, hydro, biomass and geothermal heat have been adopted as a capable substitute towards meeting the current increasing demand for energy and are considered as green power because of the negligible impact on greenhouse gas emissions. Among the renewable technologies, solar and wind energy are omnipresent and are virtually inexhaustible. Applications of these resources have achieved great consideration in research, because it appears to be the better efficient solutions to these crises. However, due to the weather conditions, these resources generally have considerable power variations, which include voltage fluctuations and frequency variations. In recent years, storage systems have been used to design active generators, which are able to provide an energy reserve with a less fluctuating output power. The United States, European Union, China and Russia, which are among the regions of the wider world and the most populated, consume over 61% of global electricity. Between 2001 and 2012, consumption of some developing countries has increased significantly: it has been multiplied by 3.3 for China, India by 2.2 and 1.6 for Brazil[1].

Microgrids are low-voltage distribution systems consisting of various controllable Distributed Energy Resources (DERs), energy storage units and controllable loads, which can be operated in either loads based on the present and forecasted information islanded or grid-connected mode. Proper operation of a microgrid

requires an Energy Management Strategy (EMS). An EMS is a computer-aided tool used by power system operators to monitor and controls the power flows in the microgrid by adjusting the power imported/exported from/to the main grid, the dispatchable DERs and the controllable of the market, the generations, and the loads in order to meet the operational objectives.

A smart home is a house that uses new technologies to monitor the in-house temperature, out-house climate change, control and monitor the home appliances and communicates with worldwide. Smart home have the potential of increasing energy efficiency, decreasing cost of energy use. Several projects have proposed to minimize the electricity consumption using Home energy Management System[2-10].

Pressure-based floor sensors are utilized to achieve efficient retrieval and summarization of video and audio data. When a pressure-based floor sensor detects the person's movement, the information is analyzed to index the video and audio data. This demonstrates efficient multimedia services for the human movement patterns[2]. Design of intelligent agents and the role of prediction algorithms, is focused based on the inhabitants' repetitive actions to automatically provide adaptive home services[3]. The Smart Aware Home project is dealt with decisions about the inhabitants' location and movement detection within a house, utilizing multi-camera tracking, audio/video sensors and automated disjointing of sound sources. Secondly, the research effort for providing more convenient and smart services for home environments has also been conducted[4]. The ZigBee home network systems utilized pressure-based floor sensors to achieve efficient recovery and summarization of video and audio data. When a pressure-based floor sensor detects the person's movement, the information is analyzed to index the video and audio sensor data. This demonstrates efficient multimedia services for the human movement patterns[5]. TV-oriented design is proposed to manage data broadcasting services, based on a common purpose platform middleware[6]. Challenging issues for the provision of healthcare services in the home arena is discussed in detail[7]. A ubiquitous sensing room equipped with cameras, various sensors and RFID to measure natural daily human behavior was discussed[8].

In this paper, a SHEMS is designed and implemented to monitor and control home appliances have been proposed. The solar and wind power system are used along with Lead-acid battery. Arduino controller is employed to solve the energy management in microgrid, which switch the supply to the loads through relay depending upon the available resources.

I. Methodology

The block diagram of Arduino controlled Smart Home Energy Management System Using Renewable Energy resources is shown in Figure 1.

A. Arduino Uno

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. "Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform.

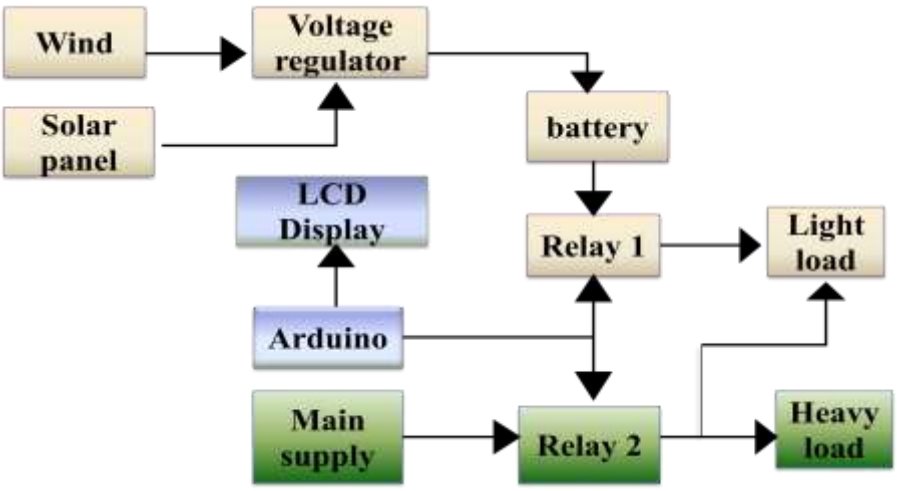

Figure1. Block Diagram of SHEMS using Renewable Energy

B. Solar Power

Solar panel is used to absorb the sun rays at day time and take a backup for use it night time. The electrons flow between the two layers. The flow makes an electric current. The current can leave the cell through the metal contacts and be used. When light hits a solar cell, much of its energy is wasted. Some light bounces off or passes through the cell. Some is turned into heat. Only light with the right wavelength, or colors, is absorbed and then turned into electricity.

C. Wind Power

Wind mills or turbines works on the principle of converting kinetic energy of the wind in to mechanical energy. Wind results from air in motion due to pressure gradient that is caused by the solar energy irradiating the earth. Wind possesses energy by virtue of its motion. Any device capable of slowing down the mass of moving air can extract part of the energy and convert into useful work.

D. Lead Acid Battery

Lead acid battery is used as a storage unit for wind and solar power generation. Large-format lead-acid designs are widely used for storage in backup power supplies in cell phone towers, high-availability settings like hospitals, and stand-alone power systems.

E. Single Pole Single Throw Relay

The relay module is an electrically operated switch that allows you to turn on or off a circuit using voltage and/or current much higher than a microcontroller could handle. The relay protects each circuit from each other. The each channel in the module has three connections named NC, COM, and NO. Depending on the input signal trigger mode, the jumper cap can be placed at high level effective mode which 'closes' the normal open (NO) switch at high level input and at low level effective mode which operates the same but at low level input.

F. Voltage Regulator

The L7812 series of three-terminal positive regulators is available in TO-220, TO-220FP, TO-3 and D2PAK packages and several fixed output voltages. These regulators can provide local on-card regulation, eliminating the distribution problems associated with single point regulation.

G. Modeling of Electrical Load

The electrical load of the house is the total power consumed per day by all the appliances and electronics in the house hold. There are two types of Loads, viz., Heavy load and Light load. Electric Motor, Air

conditioner, Washing Machine, Refrigerator, Heater are considered as heavy loads. Lighting, fan are considered as light loads.

III. Implementation

The schematic diagram of Arduino controlled Smart Home Energy Management System using Renewable Energy resources is shown in Figure 2.

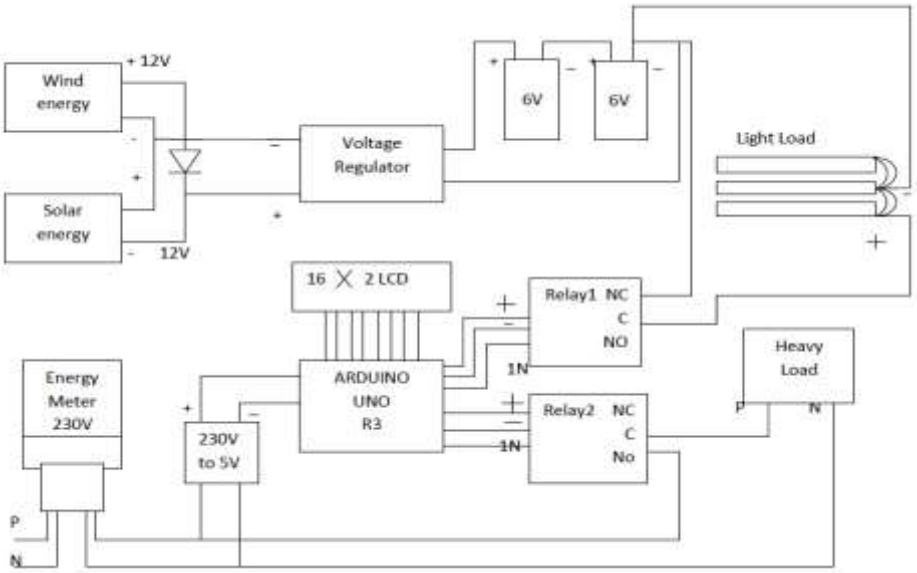

Figure 2. Schematic Diagram of SHEMS using Renewable Energy

In this work, the solar panel consists of 18 cells, and is made up of Poly crystalline silicon cell. The output voltage of the panel varies from 7V to 13.5V. In order to maintain the constant voltage, a 12V regulator is fixed along with solar panel. In wind source, 5V DC motor is used instead of windturbine that is coupled with 12V DC motor that converts the mechanical energy to electrical energy and gives 12V. Diode is employed in the work to avoid reversible power flow from solar panel to wind source. Voltage regulator LM7812 is incorporated to provide the regulated output. The power from solar and wind is given to te voltage regulator which regulates the Voltage. 5V SPST Relay is used in this work which is controlled by Arduino controller. The Relay circuit performs switching of power supply between the reneweable sources and the main supply. The hardware implementation of the proposed work is shown in Figure 3.

Figure 3. Hardware implementation

A. Distribution Supply Mains Off

As per the scenario 1 from the Table 1, When the solar and the wind is kept ON the baterry gets automatically charged.During this condition, the relay 1 is trigerred using the Arduino.As a result,Light load glows by discharging power from the battery.

Table 1. Performance of the proposed work when distribution supply mains OFF and ON

Condition	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Distribution supply mains OFF	Solar-ON Wind-ON Battery-charging/discharging Light load-ON	Solar-ON Wind-OFF Battery-charging/discharging Light load-ON	Solar-OFF Wind-ON Battery-charging/discharging Light load-ON	Solar-OFF Wind-OFF Battery-Discharging Light load-ON
Distribution supply mains ON	Solar-OFF Wind-OFF Heavy Load-ON Light load-ON	Solar-ON Wind-ON Heavy load-ON Light load-ON	-	-

As per the scenario 2, When the solar is kept ON and the wind is kept OFF the baterry gets automatically charged.During this condition, the relay 1 is trigerred using the Arduino.As a result,Light load glows by discharging power from the battery.As per the scenario 3, When the solar is kept OFF and the wind is kept ON the baterry gets automatically charged.During this condition, the relay 1 is trigerred using the Arduino. As a result,Light load glows by discharging power from the battery. As per the scenario 4, When the solar and the wind is kept OFF the baterry does not get charged.During this condition, the relay 1 is trigerred using the Arduino.As a result,Light load glows by discharging power from the battery.

B. Distribution Supply Mains On

As per the scenario 1 from the above Table 1, When the solar and the wind is kept OFF , the relay 2 is trigerred using the Arduino and is switched to the main supply.As a result,both heavy and light load glows by the main supply. As per the scenario 2, when solar and wind resources is ON the both the loads work from the main supply.

IV. Conclusion

Arduino controlled SHEMS using Renewable Energy resources has been successfully design and implemented. In this paper, the main focus is the development of an independent energy generation module for smart homes. The facilities are affordable and even domestic user can provide themselves a micro generation system in their own home. The developed SHEMS is environmental friendly since it encourages the use of renewable energies to save the environment. This work is beneficial for the people in remote areas.

The work seeks to increase the awareness of public and private sector energy stakeholders regarding the availability of cost-effective applications of renewable energy technologies, and to strengthen stakeholder capacity to implement renewable energy projects.

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